

Future Operation Scenarios

RHIC performance overview

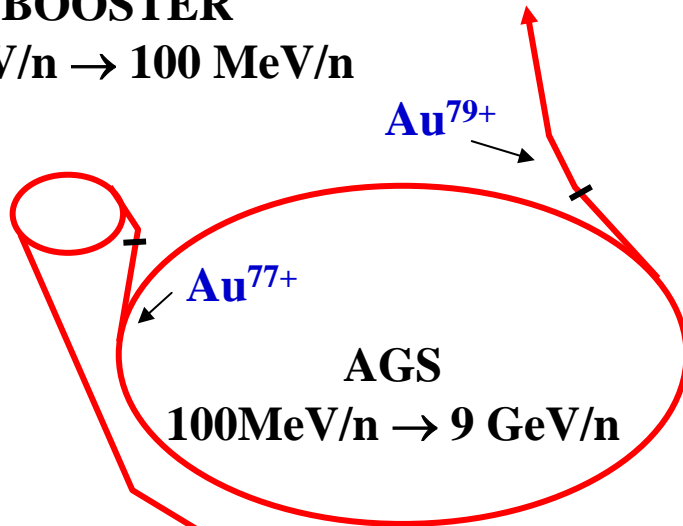
Luminosity and polarization evolution
(towards “enhanced luminosity”)

EBIS

Injector performance – bright bunches for collider

BOOSTER

1 MeV/n \rightarrow 100 MeV/n



AGS

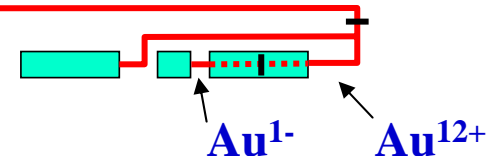
100 MeV/n \rightarrow 9 GeV/n

	<u>Intensity/RHIC bunch</u>	<u>Efficiency[%]</u>
Tandem	5.4×10^9	
Booster Inj.	2.9×10^9	54
Booster Extr.	2.4×10^9	83
AGS Inj.	1.2×10^9	50
AGS Extr.	1.1×10^9	<u>92</u>
Total		20

Emittances: $10 \pi \mu\text{m}$, 0.3-0.4 eVs/n
Limit: Beam induced gas desorption at Booster injection.

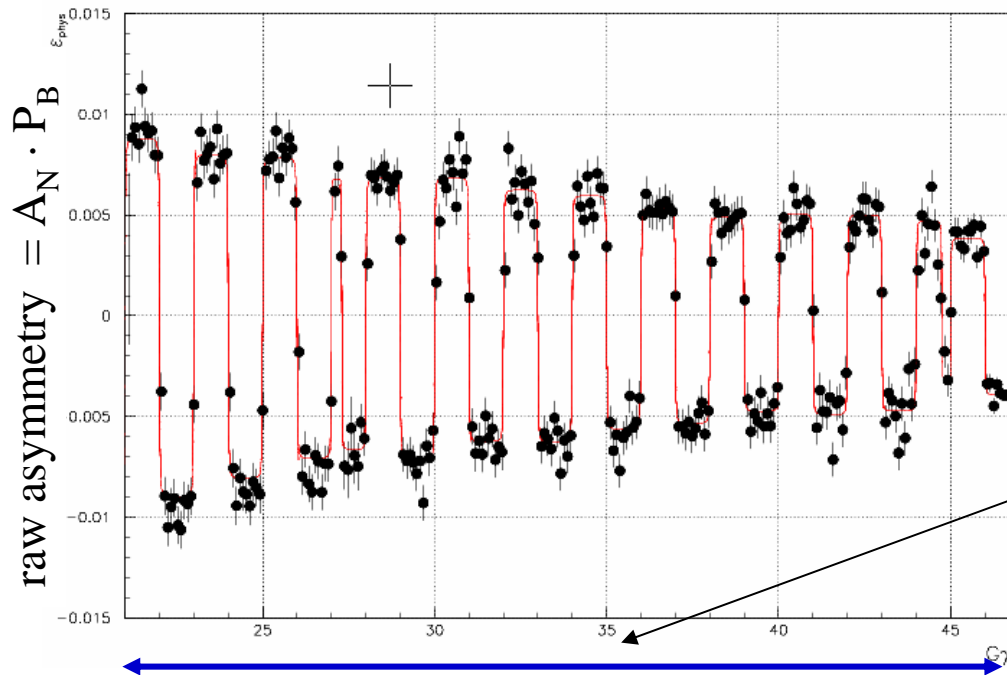
Au^{32+} : 1.4 part. μA , 530 μs (40 Booster turns)

TANDEMS

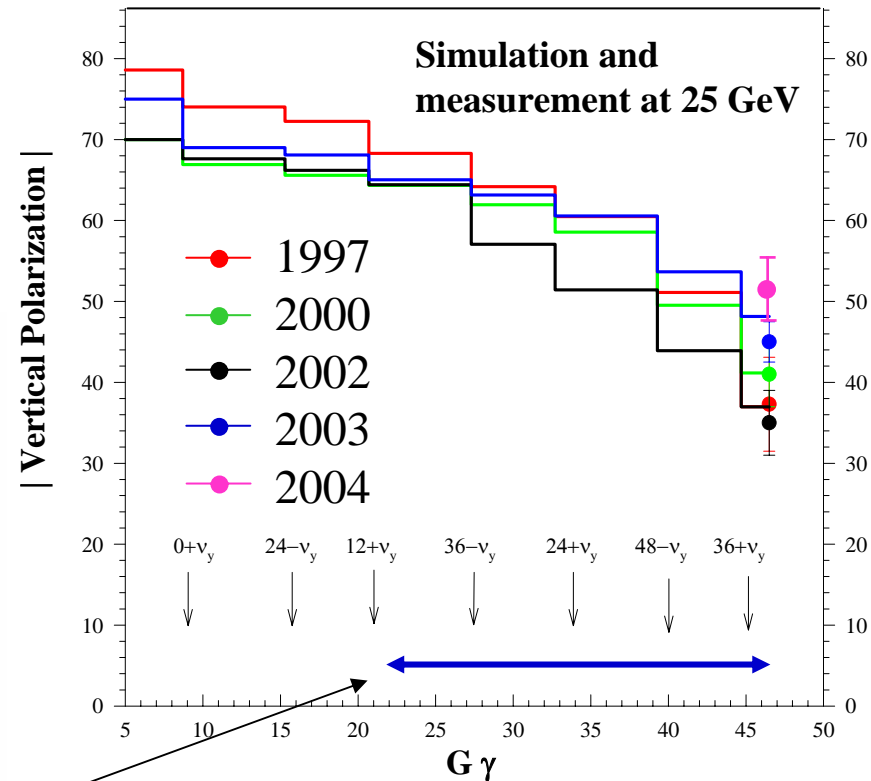


Proton polarization at the AGS

- Full spin flip at all imperfection and strong intrinsic resonances using partial Siberian snake and rf dipole
- Ramp measurement with new AGS pC CNI polarimeter:

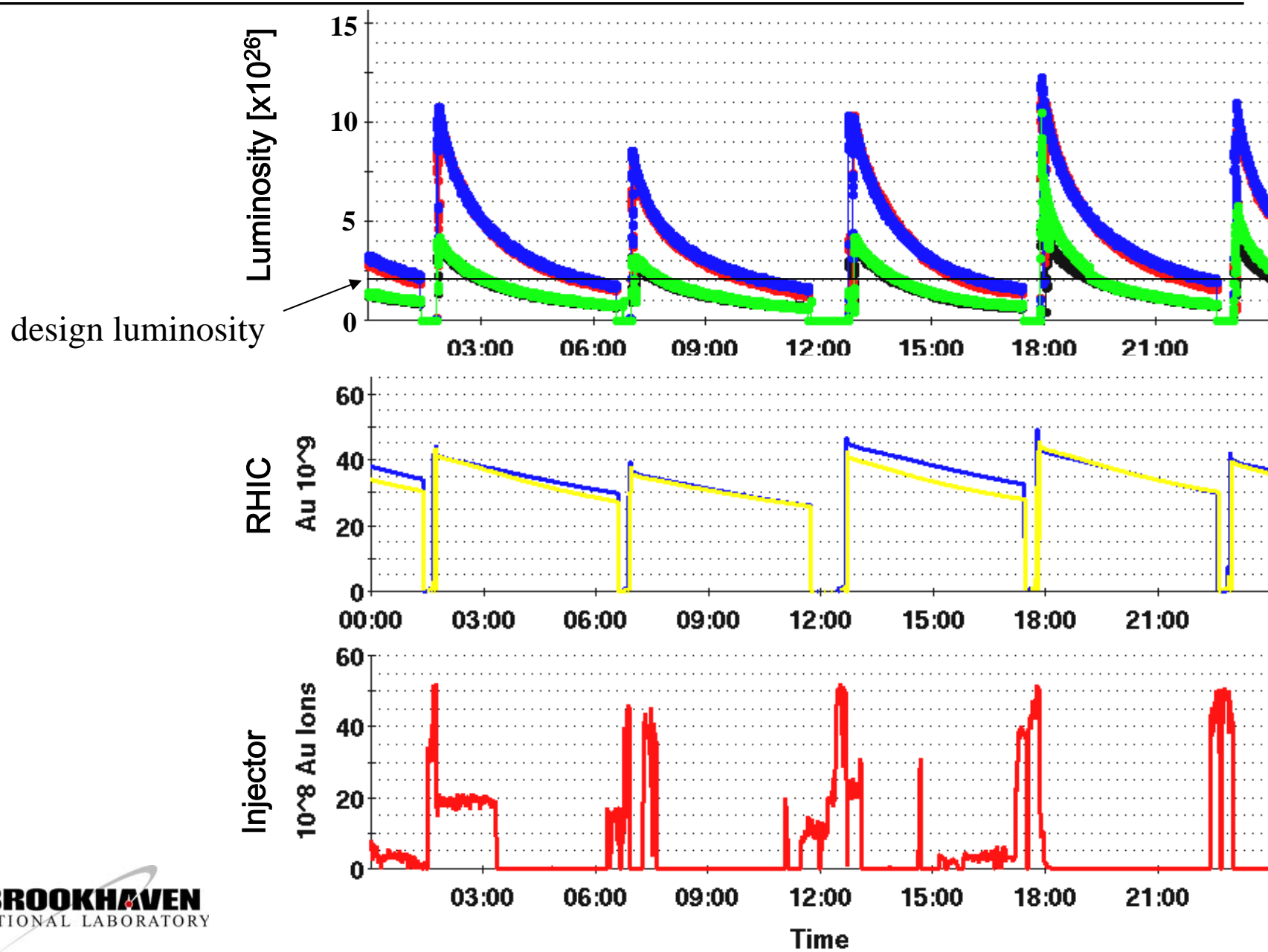


2005: 55%, 1×10^{11} ppb



- Remaining polarization loss from coupling and weak intrinsic resonances
- New helical partial snake (RIKEN funded) eliminated coupling resonances
- Strong super-conducting helical partial snake will eliminate all depolarization.

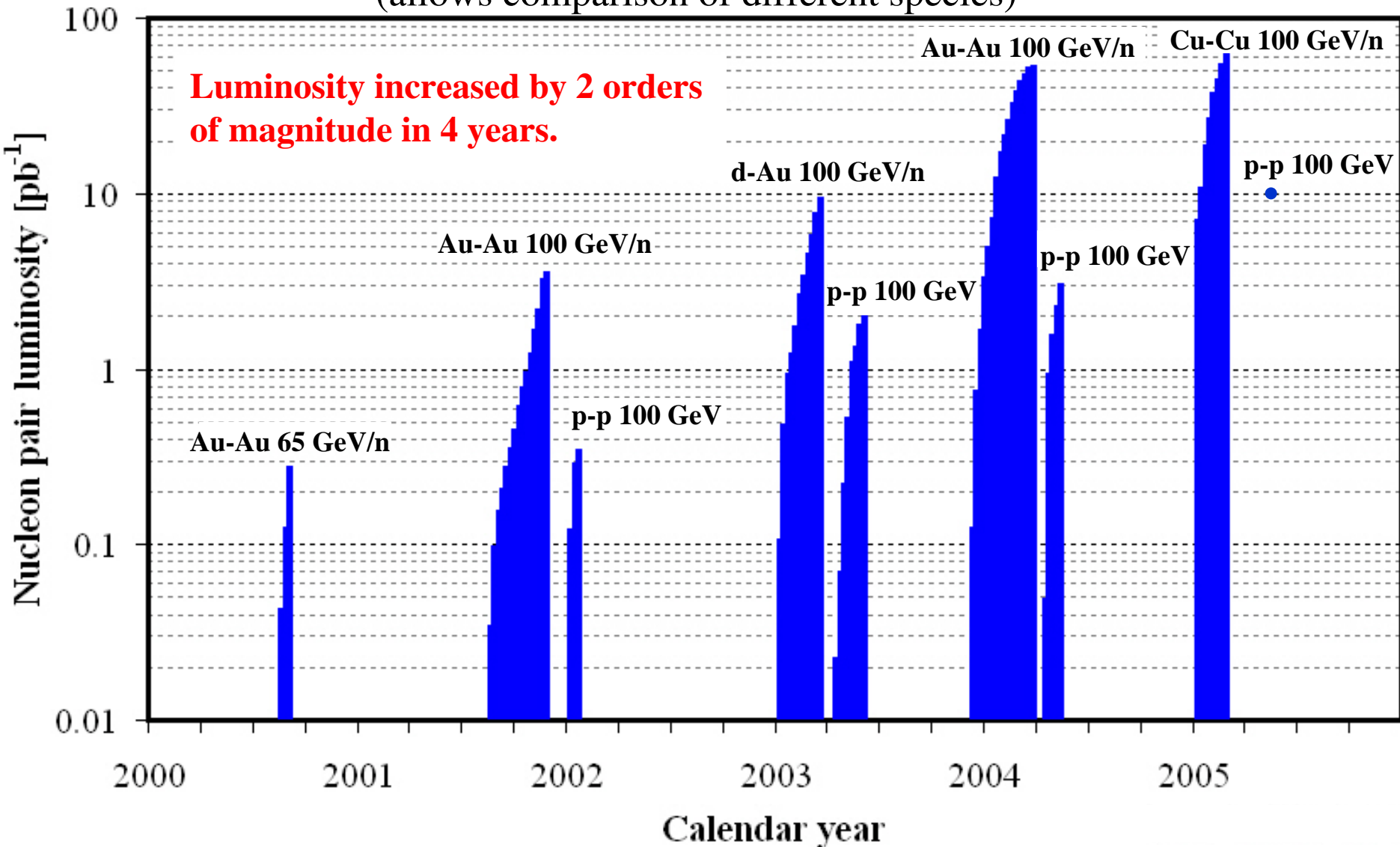
RHIC Au-Au performance – 2 x design luminosity



RHIC – a Uniquely Flexible High Luminosity Collider

Nucleon-pair luminosity $A_1 A_2 L$ delivered to PHENIX
(allows comparison of different species)

**Luminosity increased by 2 orders
of magnitude in 4 years.**



RHIC design and achieved parameters

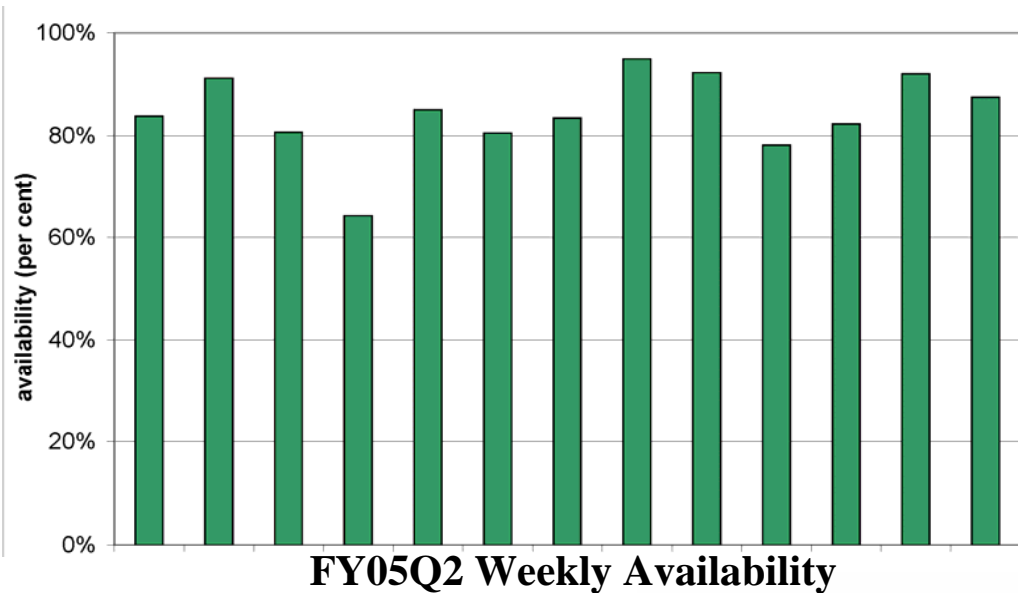
Mode	No of bunches	Ions/bunch [10 ⁹]	β^* [m]	Beam pol.	$L_{\text{store ave}}$ [cm ⁻² s ⁻¹]	$A_1 A_2 L_{\text{store ave}}$ [cm ⁻² s ⁻¹]	$A_1 A_2 L_{\text{peak}}$ [cm ⁻² s ⁻¹]
Design values (1999)							
Au – Au	56	1.0	2		2×10^{26}	8×10^{30}	31×10^{30}
p – p	56	100	2		4×10^{30}	4×10^{30}	5×10^{30}
Achieved values (up to 2005)							
Au – Au	45	1.1	1		4×10^{26}	16×10^{30}	58×10^{30}
d – Au	55	120/0.7	2		3×10^{28}	6×10^{28}	24×10^{30}
Cu – Cu	36	4.5	1		80×10^{26}	32×10^{30}	79×10^{30}
p↑ – p↑	84	80	1	50%	8×10^{30}	8×10^{30}	11×10^{30}
p – p	56	170	1		10×10^{30}	10×10^{30}	15×10^{30}

Other high luminosity hadron colliders:

$$L = \frac{3 f_{\text{rev}} \gamma}{2} \frac{N_B N^2}{\epsilon \beta^*}$$

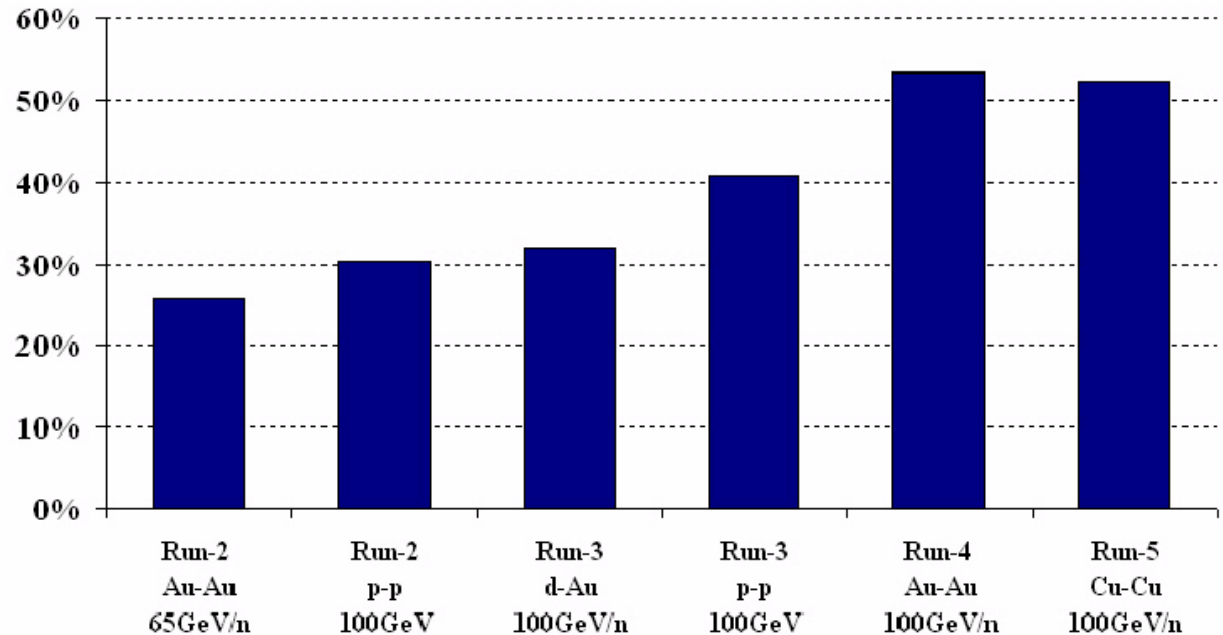
	achieved	goal	scaled to 200 GeV
Tevatron (2 TeV)	128×10^{30}	200×10^{30}	20×10^{30}
LHC (14 TeV)		10000×10^{30}	140×10^{30}

RHIC availability and time in store



- Excellent availability despite very complex operation modes.
- Machine set-up time reduced to just 3 weeks.

RHIC time in store



Future plans for RHIC

Machine goals for next few years with upgrades in progress:

- Enhanced RHIC luminosity (112 bunches, $\beta^* = 1\text{m}$):
- Au – Au: $8 \times 10^{26} \text{ cm}^{-2} \text{ s}^{-1}$ (100 GeV/nucleon)
- For protons also 2×10^{11} protons/bunch (no IBS):
- $p\uparrow - p\uparrow$: $60 \times 10^{30} \text{ cm}^{-2} \text{ s}^{-1}$; 70 % polarization (100 GeV)
 $150 \times 10^{30} \text{ cm}^{-2} \text{ s}^{-1}$; 70 % polarization (250 GeV)
(luminosity averaged over store delivered to 2 IRs)

2 × achieved

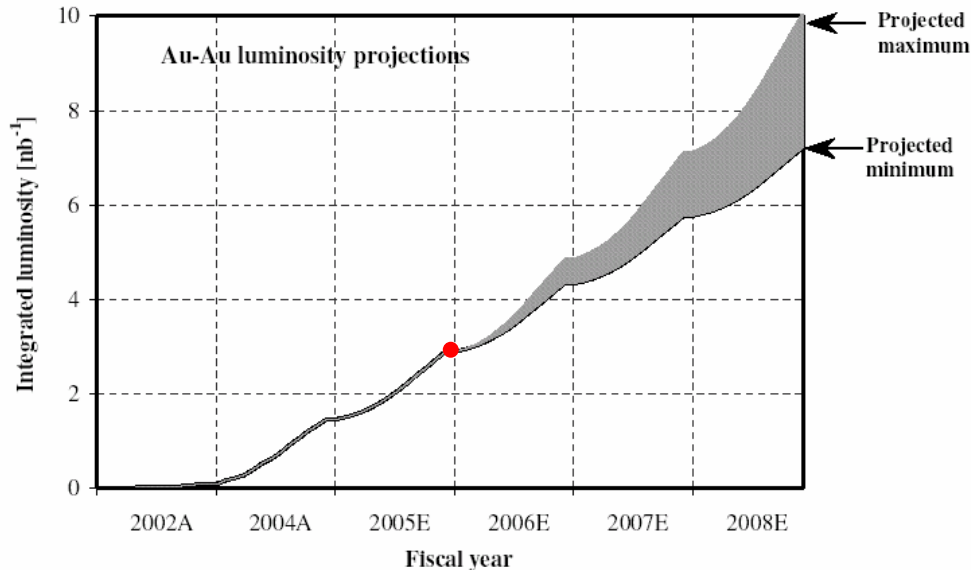
6 × achieved !!

EBIS (low maintenance linac-based pre-injector; all species incl. U and pol. He3; avoid Tandem investment; ~ 3 year pay-back period)

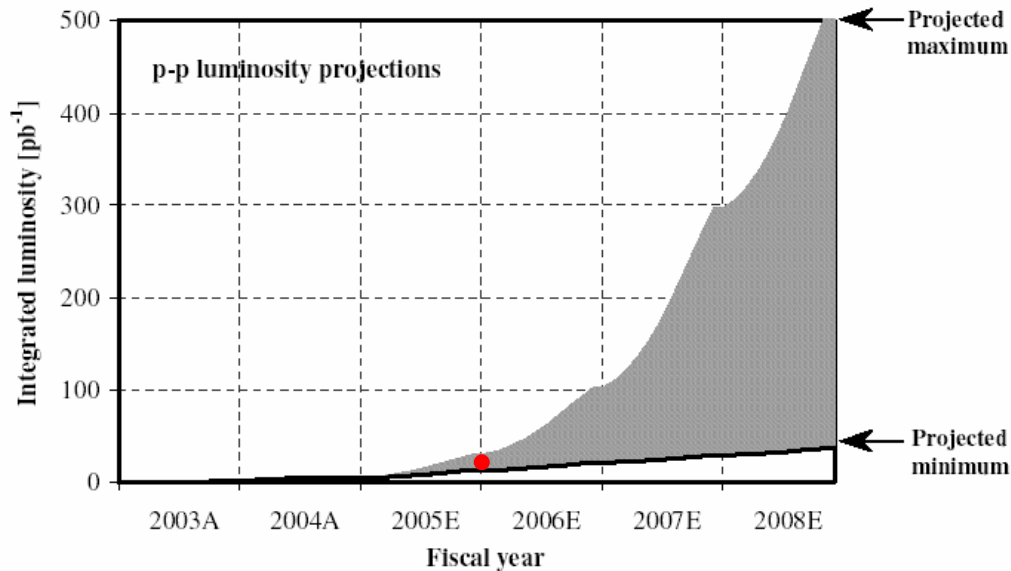
RHIC luminosity upgrade (e-cooling, ~10 × more luminosity, R&D in progress)

eRHIC (high luminosity ($1 \times 10^{33} \text{ cm}^{-2} \text{ s}^{-1}$) eA and pol. ep collider)

“5-year” projections



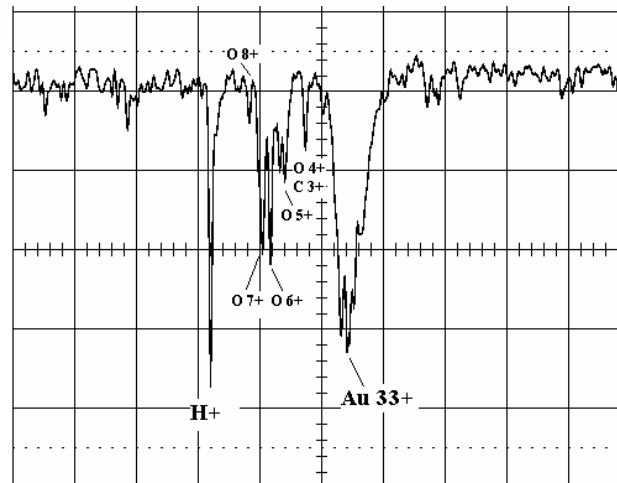
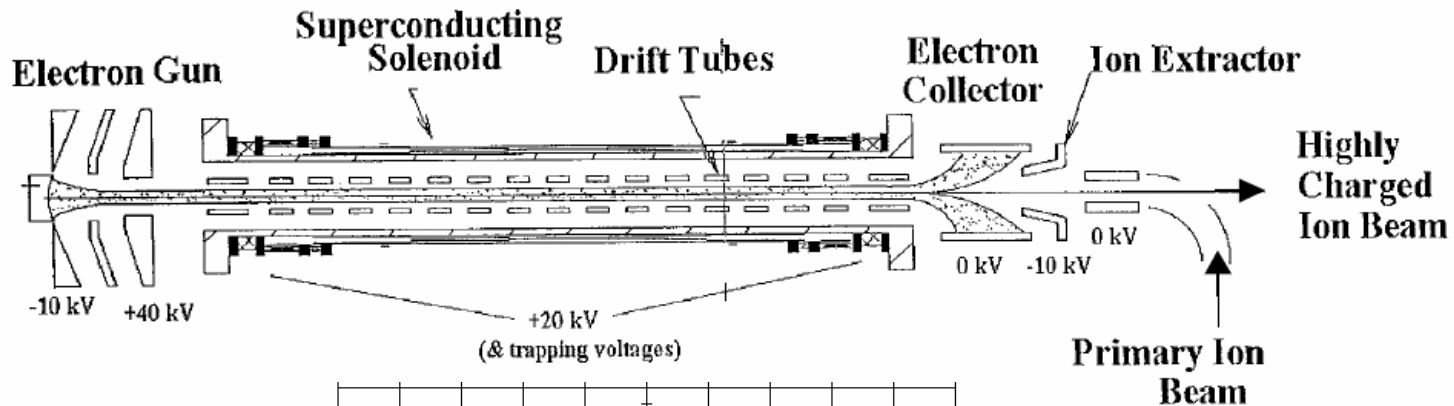
Au-Au projections:
Cu-Cu scaled to Au-Au:
Excellent agreement



pp projections:
3 instead of 2 exp. \rightarrow half lumi.
Beam-beam limit/IR: 0.0035
Expect: 0.007

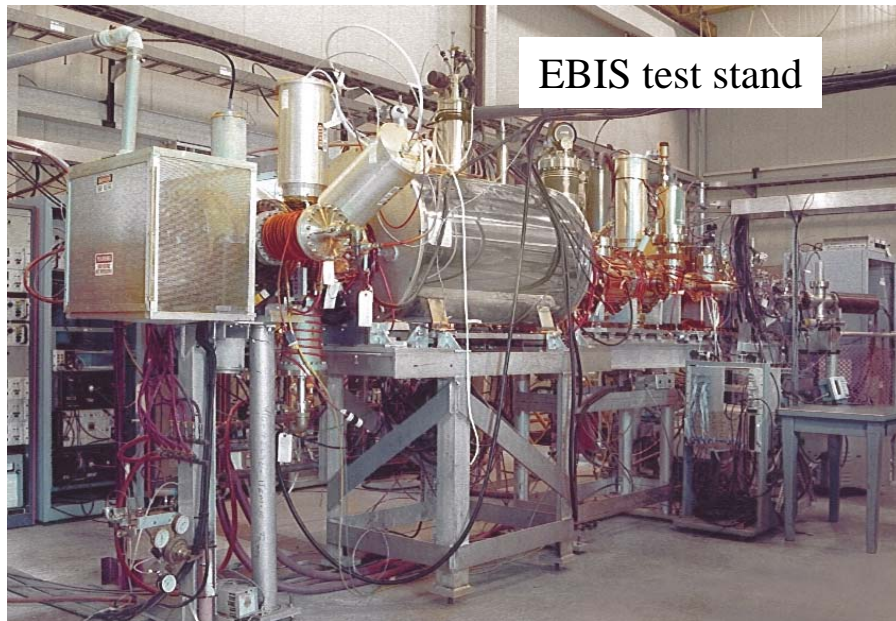
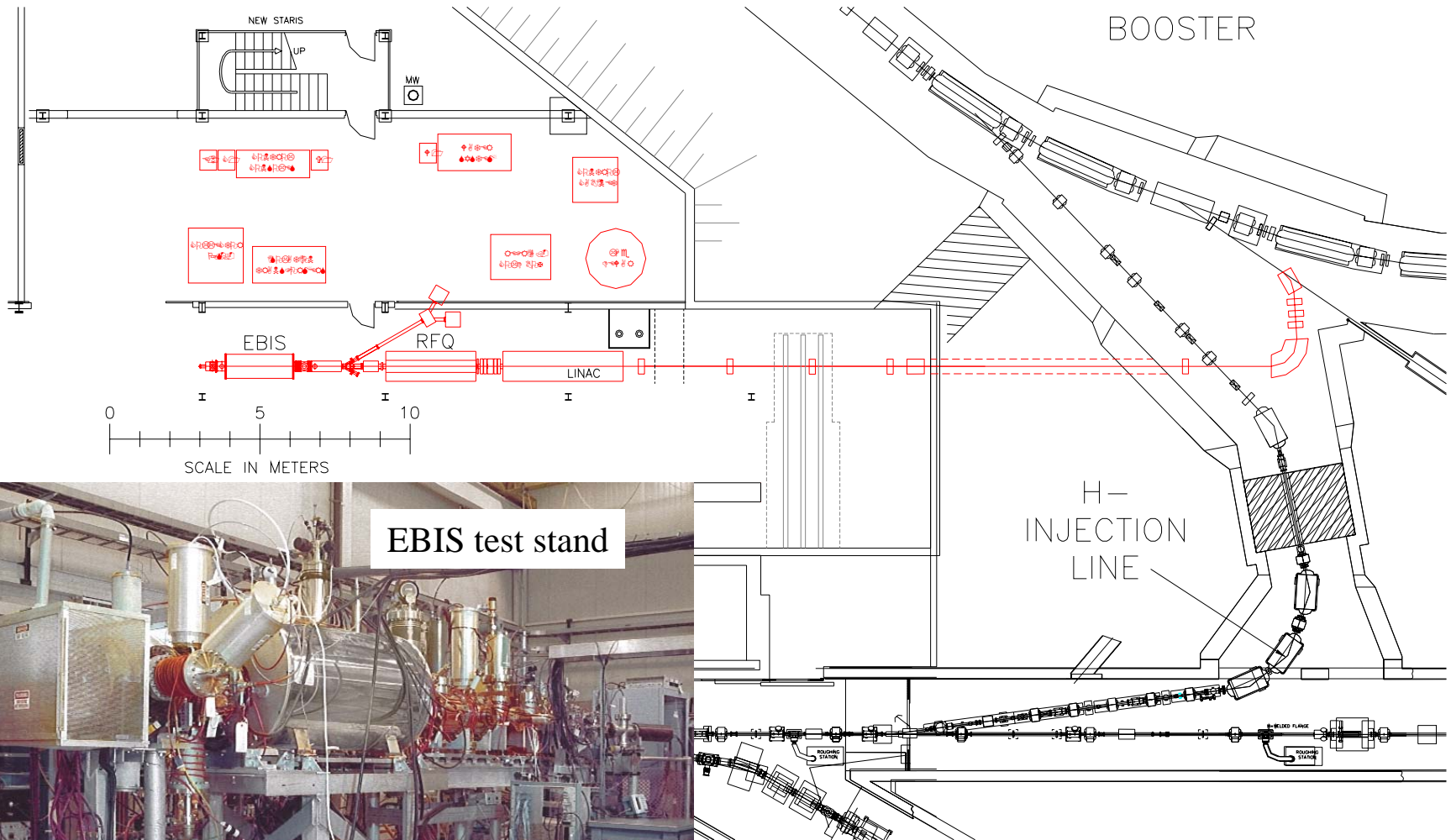
Electron Beam Ion Source (EBIS)

- New high brightness, high charge-state pulsed ion source, ideal as source for RHIC
- Produces beams of ALL ion species including noble gas ions, uranium (RHIC) and polarized He^3 (eRHIC)
- Achieved $1.7 \times 10^9 \text{ Au}^{33+}$ in 20 μs pulse with 8 A electron beam (60% neutralization)
- CD0 received, CD1 review in July 2005, construction schedule: FY2006 – 09



Gold charge state with only 40 ms confinement time.

EBIS layout



Summary

Since 2000 RHIC has collided, for the first time,

- Heavy ions
- Light on heavy ions
- Polarized protons (50% beam polarization)

Heavy ion luminosity increased by factor 100

For next 4 years planned:

- Factor 2 increase in heavy ion luminosity
- Factor 6 increase in proton luminosity with 70 % polarization